INDUSTRIAL DESIGN PROJECT - 2
REPORT

PORTABLE PATIENT CHAIR FOR DENTAL CAMPS

Submitted by
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Portable Patient Chair for Dental Camps

IDP 602 : Project II

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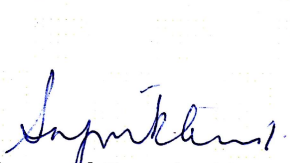
APPROVAL

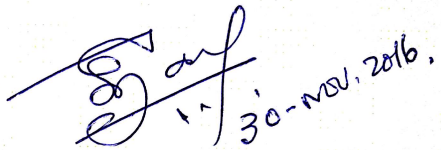
Industrial Design Project II

“Portable Patient Chair for Dental Camps”
By: Arun Shah,
156130016
M. Des Industrial Design 2015-17

Is approved as a partial fulfillment of requirements of post graduate Degree in Industrial Design at IDC, IIT Bombay.



External Examiner



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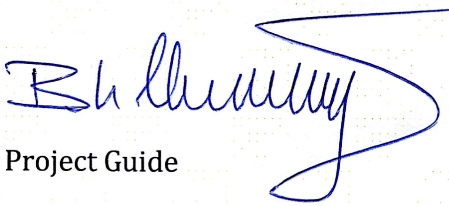

Project Guide

Chairperson

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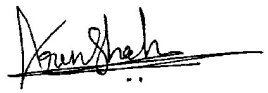
DECLARATION

I declare that this written submission represents my idea in my own words and where other ideas or words have been included, I have adequately selected and referred the original source.
I also declare that I have adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any ideas / data / facts / sources in my submission.
I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources that have not been properly cited, or from whom proper permission has not been sought.



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ACKNOWLEDGMENT

This work would not have been possible without my friends and faculty here at IDC. I wold like to thank My guide, Prof B.K Chakravarthy, for all the valuable inputs and directions.

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Dr. Neeraj Rohida, Mumbai and Dr. Suyog sawant, Bharti VIdhyapeeth, Navi Mumbai.

Also would like to thank IDC workshop staff (PD cell especially), my friends and family for all the support.

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Contents

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Motive

My researches in dentistry had begun when I was doing a collaborative course with BETiC lab at IIT Bombay. I was working with a group of students, and was working on developing a dental equipment for lighting in dental surgeries. We had done a background study in dentistry and the issues related in it. In focus, we also studied about the dental chair. There were many issues that we were trying to address. Portability dental chair was one of the issues that came across to my attention. From earlier conversations with dentists, I had got an idea of developing a portable dental chair. After the completion of the course with BETiC, this project was taken forward and I did my research on this specific issue. The chair is not just a chair for the patients, it is also the work station for the dentists. This understanding of the usability of the chair is what triggered the design thinking for me. This project gave me lot of experiences and a lot of insights in the field of Indian dentistry. In the following chapters I will describe in detail the process of the designing of this product and the insights and scope of this project.

Objectives & Methodology

- **To Conduct a Research Understand the current scenario of;**
  - Indian Dentistry
  - Dental health in India
  - Dental health care in rural areas

- **To Study the Need**
  - To conduct User studies and Evaluations
  - Market studies and research

- **To Redesign a Dental equipment for the betterment of the Rural dental healthcare and activities**

User research

Analysis

Problem definition

Idea explorations

Concepts

Prototyping

Section 1.
Overview – Dentistry in India

Fig. 1.1
Dr. R H Ahmed

Dr. R. H. Ahmed was perhaps the first certified dental practitioner in India. He enrolled in the University Of Iowa School Of Dentistry, earning his dental degree in 1915. Dr. Ahmed then worked in the Forsyth Dental Infirmary for Children in Boston, Massachusetts, until 1918. In 1919, he returned to India to open a dental practice in Calcutta. In India there were no trained professionals for dentistry until the beginning of the twentieth century.

Even now India lacks enough dentists available for service. More than 70% of Indian population is residing in rural areas and a major portion is below the poverty line. At present, India has one dentist per 10,000 population in urban areas and for about 2.5 lakh persons in rural areas. Unequal and Uneven Geographic distribution of Dental Colleges All over India, makes unavailability of dentists even worse in certain areas. Most of the colleges in each of the Indian states are concentrated in the urban centers. So cities are becoming the hub for dental treatment. The high cost of dental treatment, illiteracy, lack of awareness, poor accessibility to dental clinics and repeated dental appointments are the reasons for which most patients rely on Street dentists and quacks. Most of the quacks learn some dental work while working as an assistant in dental clinics. They are able to acquire a mere knowledge by just simple observation of the dental operating procedures with no scientific knowledge and then start off their own practice in rural areas at a low cost, without using any technology and modalities.

Fig. 1.2. Street Dentists in India

They are least concerned about the sterilization of their instruments and devise their own instruments according to their convenience which has no scientific basis. They perform many dental procedures like extraction, fixing the tooth, filling the tooth, dental bleaching & excavation of caries. They don't have proper instruments and they mostly use modified old instruments. Instruments are not autoclaved.
Local anesthesia is not administered properly. Many times alcohol is also administered to reduce the pain sensation by sedating the patient.

Dental disease is a serious public health problem with universal distribution and affecting all age groups. However, despite this universal distribution, only a few seek dental care. The Government of India and Dental council of India can take initiatives to open new dental colleges in peripheries and there should be one dentist in each Primary Health Centre. In India, people encounter various obstacles in utilization of dental services. These barriers can be removed by motivating people and making them aware about the oral health problems that remove anxiety and fear so that they develop positive attitude towards dental treatment. It is suggested that mobile dental clinics, dental camps, and dental outreach programs could be solutions to spread awareness and disseminate treatment.

Fig 1.3. Dental Camps in India

1.1. Dental camps

Dental camps are an efficient method in providing professional dental healthcare for rural patients. They are conducted all over India both at urban and rural areas including remote villages, at schools, public health centers, local government bodies, private centers etc. Camps are organized by different enterprises. Dental schools, Government organizations, Local bodies, NGOs and Welfare clubs and so on. Sometimes students from US and Europe also join in as part of their field work. Dentists and dental students come visit places with the needed facilities and tools, they provide primary check-ups, treatment and diagnosis.

The primary objective of camps are spreading awareness and education about oral health among people. The main operations provided at dental camps include, tooth extraction, scaling etc.
A patient spends about 5 - 10 min for a normal check-up, unless it is a surgery or a specific operation.

Section 2.
User Research

To further study the issue, I had visited some places and met with people. I will brief out the details of the visits.

1. The first person I visited was Dr. Neeraj Rohida, Dentist at **Nahar health center, Mumbai**
He was the person who suggested the area of work first. The dental chair and its portability was one of the main concerns to him. He also emphasized that, there should be provision to maintain proper hygiene in the chair.

2. The second visit was at the **Nair hospital dental college, Mumbai.** There I met with three dentists, Dr. Seema Kamble, Dr. Amit Chaudhary and Dr. Hiresh Shetty. I got to know the process of dental camps.
Camps are conducted as per request from organisations, enterprises and people. Also, dental colleges have their own camps, where they go frequently, several times in a year. Dental colleges adopt a village or a school. Public health departments and Community dentistry departments of dental colleges coordinate the activities and process. Camps are also conducted at old age homes and jails etc. By this time, I also got to visit a camp site, there were about 7 students who carried out the operations, one senior professor and dentist and a technician. They just had a box full of instruments, basic hand tools and medicines. It was just a primary check-up for students. Hence they do not carry any dental chair with them. They operate on any chairs that are available at the camp site.

3. Bharti Vidyapeeth Dental College and hospital, Navi Mumbai was the next dental college that I visited. There I met Dr. Suyog Sawant, with whom I got to discuss the way dental camps are conducted in Navi Mumbai. Additional to the normal methods, the Navi Mumbai municipal corporation, conducts urban health programs, which are conducted across various centres along Navi Mumbai. The college had facilities like a dental van, which is a mobile dental clinic. Although they did not use any portable chair.

4. Govt. Dental College, Mumbai; I had visited the college and had a discussion with the dean of the college, Dr. Mansingh G Pawar. Got some info on the issues at dental camps. The college is the most active institute in case of conducting camps and spreading awareness. They also travel to far away villages for camps.

I had also visited two manufacturers where I got to talk about the market value of the product. I will brief about that in the following section.

2.1 Dental Camps- Facilities available at present

Mobile Dental Clinic

They are also called as dental vans and mobile dental ambulances which are employed with one or more electric chairs, as a proper clinic.

Dentists and students get to do complicated surgeries like root canal, by the help of this setup. Most of the dental colleges have this facility and it is a very useful one at camps.

Fig 2.1. Mobile Dental Clinics

Fig 2.2. Portable Dental Chairs

Fig 2.3. Portable Dental Units

But it cannot occupy more patients hence only patients who need advanced attention are treated in this chair.

Portable Chairs

The chair normally used by the dentists at clinics is Electric chair. It has the following features

- Ergonomic chair
- Adjustable backrest, seat height
- Adjustable headrest
- Light
- Spittoon
- Hand tools and vacuum
- Instrument tray
- Dental unit

A portable dental unit will have most of these features, but the adjustments for the chair will be mostly completely manual. The current chairs used in the camps are aluminium chairs which requires assembling. There are additional attachments that comes with the chair. The chair gives good comfort to both dentist and the patient. Most of the chairs come with backrest adjustability

Mobile Dental Units

These are units which are small enough to carry and transport. They come boxy, as suitcases. They consist of a compact air compressor, power source, vacuum pump and water reservoir and sewage sump. These equipment's can make any kind of operations possible at anywhere.

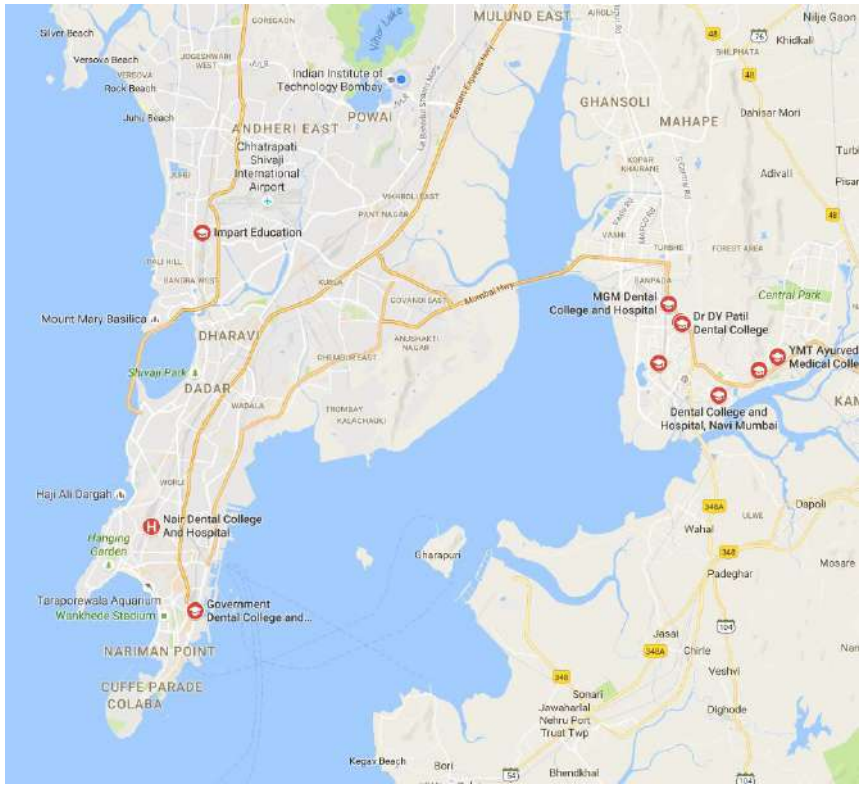


Fig. 3.1. Dental Colleges in Mumbai

Section 3.
Market Study

There is a very good market for dental chair sin India. But for portable dental chairs, there is not that much demand. Even though there is a need for the chair, the use of the chair is very less. Good quality products are either Imported or custom made by NGOs. The Good products available now are a bit overpriced as well.

I went and met two manufacturers in Mumbai.

1. Mr. Niraj Vaze Partner, Kshitij Enterprises, Sanpada, Navi Mumbai.

They are manufacturers of dental chairs and equipments. But they do not manufacture portable chairs or units. They consider the market for portable dental chairs to be having very low demand.

2. Mr. Raj Shekhar Murthy, Confident Dental Equipments, Mumbai.

This company is one of the leading manufacturers in the field of dentistry in India. They have a model of portable dental chair called Porta chair, which is sold in the market. As I mentioned earlier, they are very less Indian models in the market. A competitor(Unicorn Denamart) also manufactures the similar design. The model is mainly bought by dental colleges and NGOs.
The Porta chair is sold with the dental unit and attachments like spittoon and dental light. The chair unit has a market price of approx. Rs. 120000. The chair only will cost Rs. 30000 to 45000.

Fig. 3.2.

3.1. Porta Chair

This was the same chair that was used by the dentists at GDC Mumbai, where also, I did my user studies.

It features a full aluminium body and has provided with Padding for seating comfort. It has detachable footrest and headrest, the headrest is an Velcro-adjusted pillow.

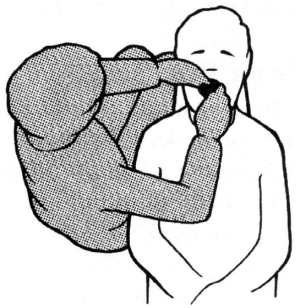
Hydraulic jack is enabled as backrest adjustment which is the easiest to operate. It also comes with a foldable armrest.

Pros

- Easy backrest adjustment (Hydraulic jack)
- Comfortable(PU padding)
- Good quality Spittoon attachment
- Comfortable headrest
- Sturdy design

Cons

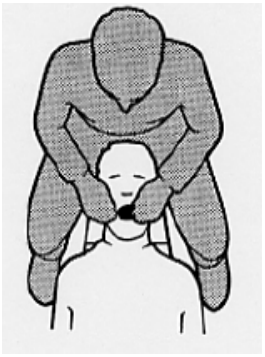
- Issues in portability(weight, absence of handles or straps, does not fold and close properly)
- Takes time for setting up (min. 15 min)
- Badly designed armrest
- Spittoon is too bulky and the joinery for the attachment difficult to set up.



8 o' clock position

9 o' clock position

10 o' clock position



12 o' clock position

Fig. 4.1

Section 4.
Working Conditions and Ergonomics

A dentist can spend up to 60,000 hours in a lifetime working in tense and distorted positions, with consequent Musculoskeletal problems.

Most of the dentists retire at the early age, due to health issues, which are, Work-Related Musculoskeletal Disorders(WMSDs). The amount of WMSDs in dentistry is as follows.

- Musculoskeletal Disorders (29.5%)
- Cardiovascular Disease (21.2%)
- Neurotic Symptoms (16.5%)
- Tumors (7.6%)
- Diseases of the Nervous System (6.1%)
- Also—eyestrain and hearing loss (hand-piece noise)

At a dental camp, the working condition for dentists are worse. The portable chair and the attachments should be designed with good ergonomics. But currently most of the working conditions are in such a way that dentists do Standing work. Even there are dental chairs which are designed for standing dentistry at camps.

Working positions;There are certain positions for dentists stated according to the working teeth /tooth of the patients(fig. 4.1). these are guidelines for better ergonomics and effective operation

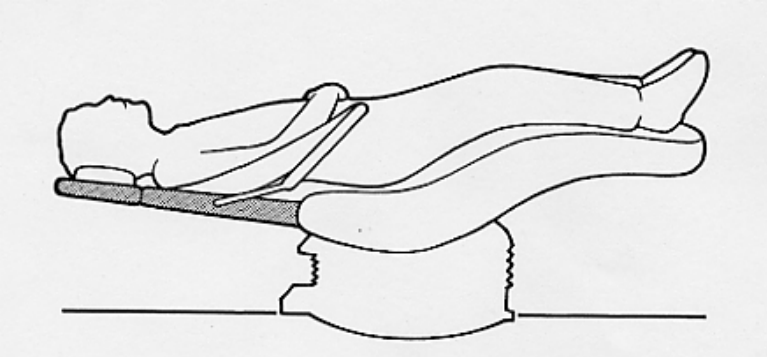


Fig. 4.2

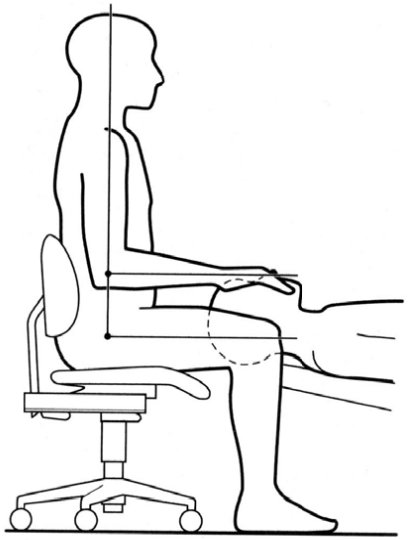


Fig. 4.3

4.1. Ergonomic working posture for Dentists according to standards

Patient position; Sitting (fig 4.2)

- Chair nearly parallel to the floor
- Heels slightly higher than nose

Patient position; Head

- Even with end of headrest
- Mandibular work (lower jaw) - chin down
- Maxillary work - chin UP
- Change patient's head position for: good visibility, access to teeth & treatment area

Clinician position (fig 4.3)

- Back against the seat back
- Entire backside on seat
- Feet flat on the floor
- Thighs parallel with the floor & hips slightly higher than knees
- Shoulders relaxed & parallel with floor
- Eyes directed downward
- ~14-16 inches distance between patient's mouth & clinician's eyes (use loupes)
- Elbows close to sides
- Patient's mouth at elbow height
- Shoulders/forearms relaxed & parallel to floor
- Knees spread apart--Hip angle slight greater than 90°. Feet flat on ground.

Section 5.
Findings

5.1. Issues in available dental chairs

Foldability - the term foldable cant be taken for granted for the chairs that are used these days. It occupies a lot of space even after folding.

Weight- the designs available right now are heavy to be carried

Adjustability- the easiness in assembling ans setting up could have been easier, like folding chairs.

5.2. Dentist's requirements according to their priority;

- Foldable chair, with adjustable backrest
- Ease in assembling and transporting
- Sturdy and durable design
- Should be maintenance free

5.3 Design considerations

Dentist's and patient's Convenience is the highest priority when it comes to dental chair.

The dental unit is a very important part of the chair, but it is not the most relevant requirement for a dental camp, a chair is.

Attachments as dental light, instrument tray and spittoon need not necessarily be part of the chair.

The design should be in such a way that, the folded chair occupies minimum space

According to dental chairs, there are positions that can be followed for good ergonomics. But in dental camps, the working conditions are different. So the chair should have the flexibility to be worked upon at any position, ensuring the dentist to be in sitting posture and he/she can work comfortably at that position.

There should be enough convenience for setting up. All assembling steps has to minimized.

The chair should be easier to maintain in terms of hygiene.

Most of the dentists has fear of instability when they work in camps. This is one of the reasons why camping chairs and relax chairs are not used for dental camps. The design should be sturdy and it should not look so light and wobbly.

Section 6.
The Design Brief

“

To redesign a portable dental patient chair for dentists to operate conveniently at dental camps, improve the portability of the existing design ensuring the sturdiness and cost effectiveness. “

Section 7.
Idea Explorations

7.1. Backrest Adjustments

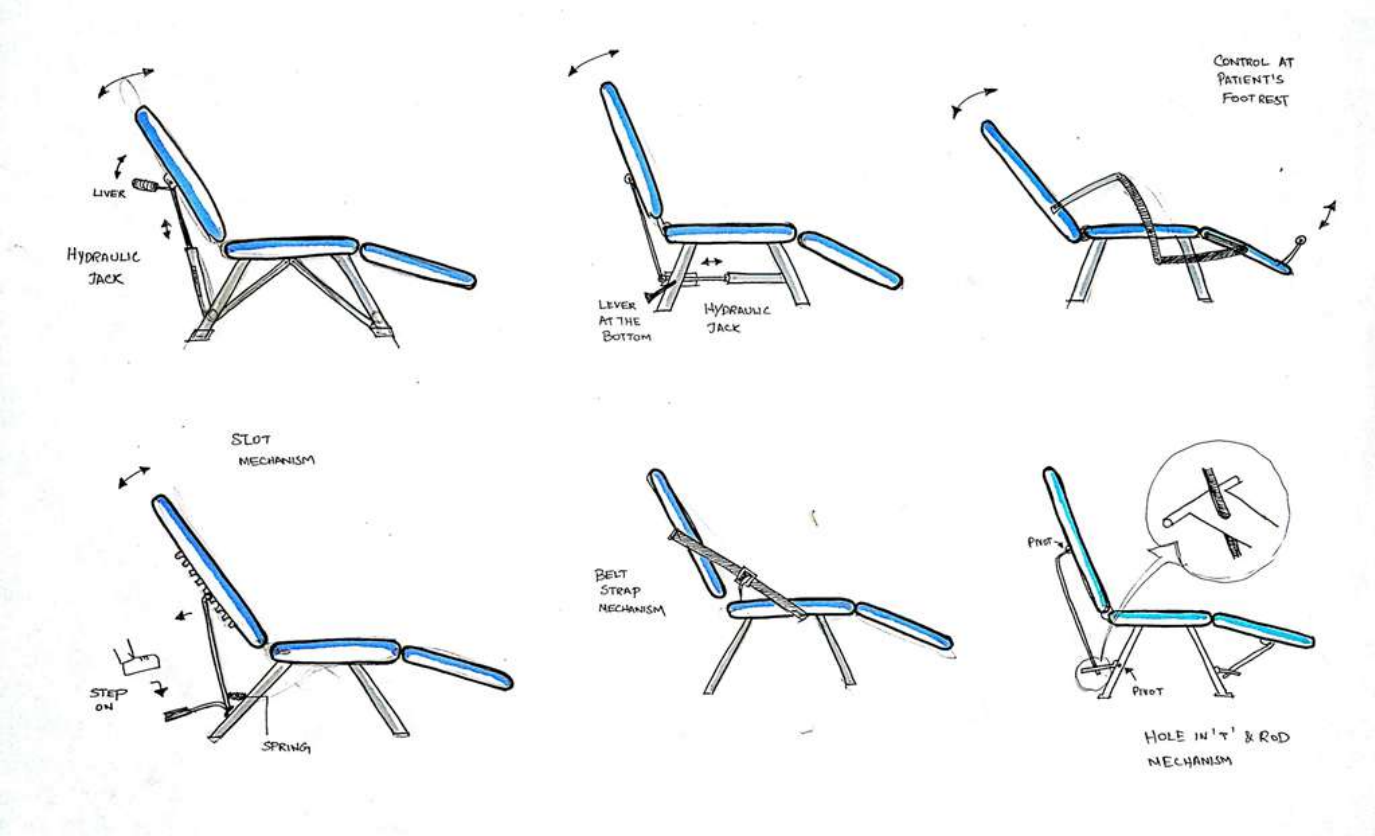


Fig. 7.1

7.2. Seat height adjustment and folding legs

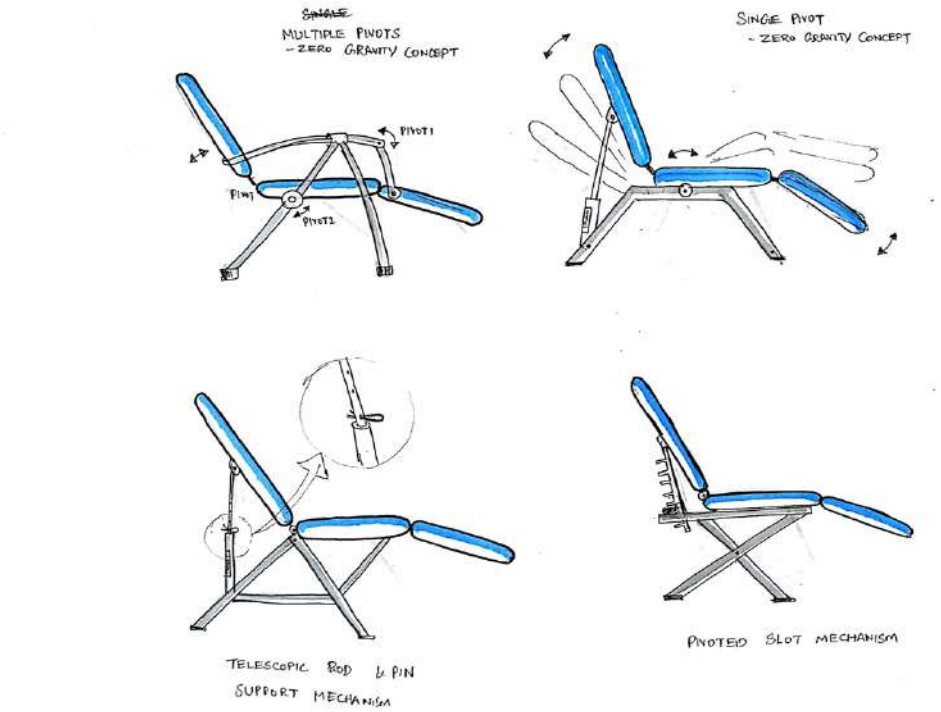


Fig. 7.2

Different mechanisms were explored for each function such as

- Backrest
- Leg folding mechanism
- Folded positions

The ideas were inspired from a wide variety of products and product mechanisms. From folding chairs camping chairs, massage chairs and many more. The existing design has similar details and Methods for the back rest adjustments. The simplest one is hydraulic jack. Including that there are mechanisms possible like belts, slots, telescopic rods etc.

Different types of folding legs and chair folded positions were also explored.

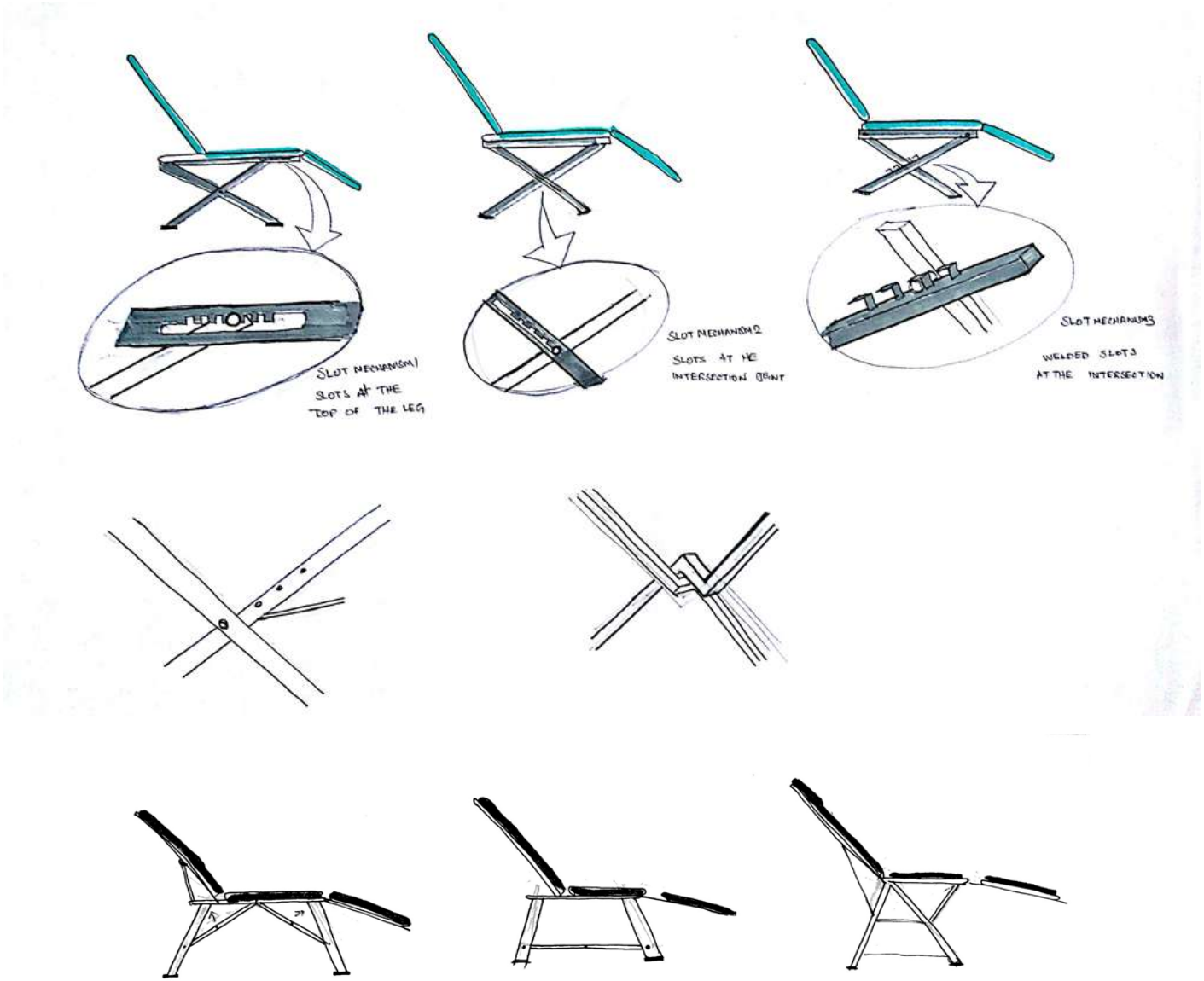

SLOT MECHANISM1
SLOTS AT THE
TOP OF THE LEG
SLOT MECHANISM2
SLOTS AT HE
INTERSECTION POINT
SLOT MECHANISM3
WELDED SLOTS
AT THE INTERSECTION

Fig. 7.3

7.3. Folded Modes

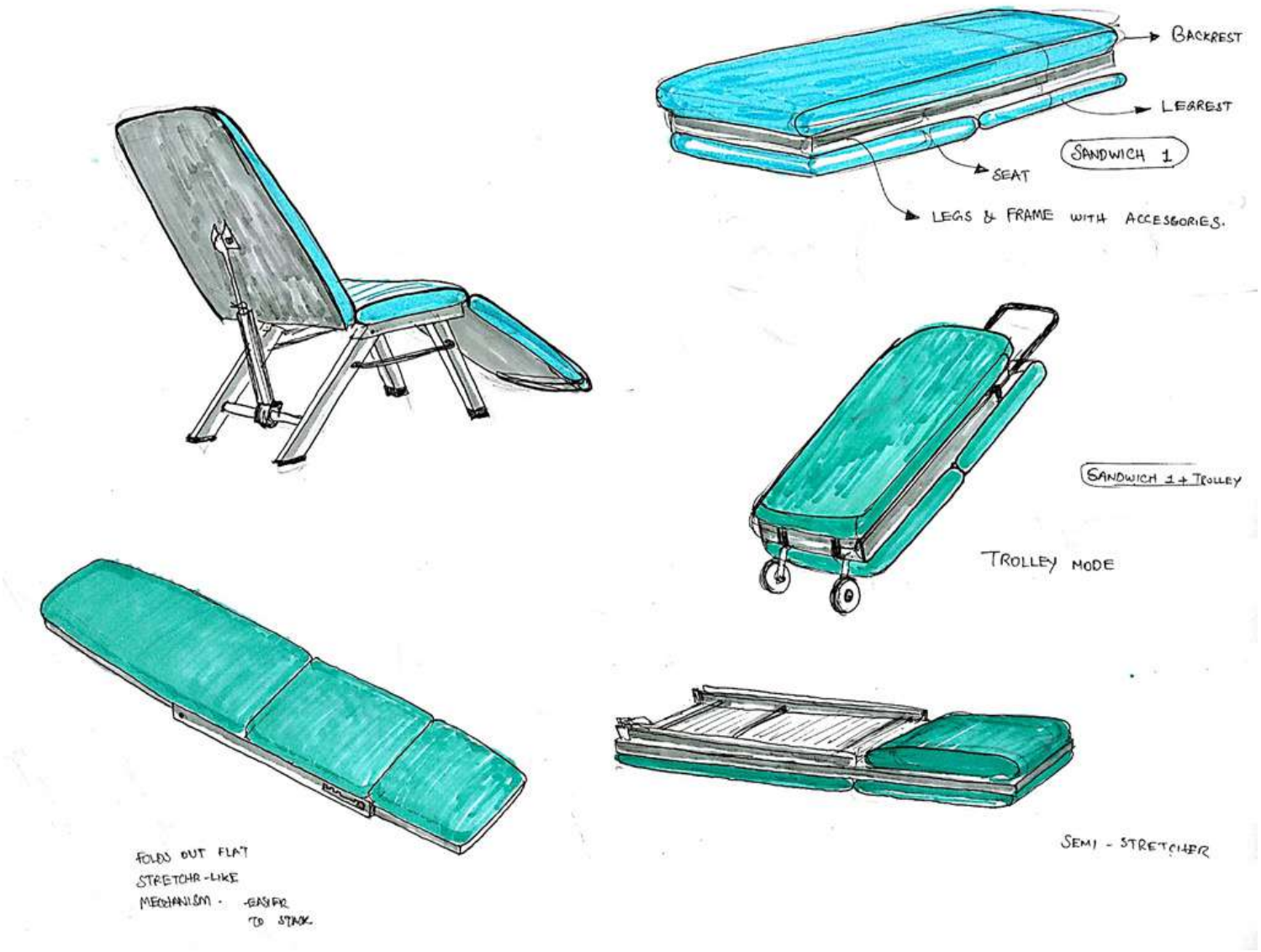


Fig. 7.4

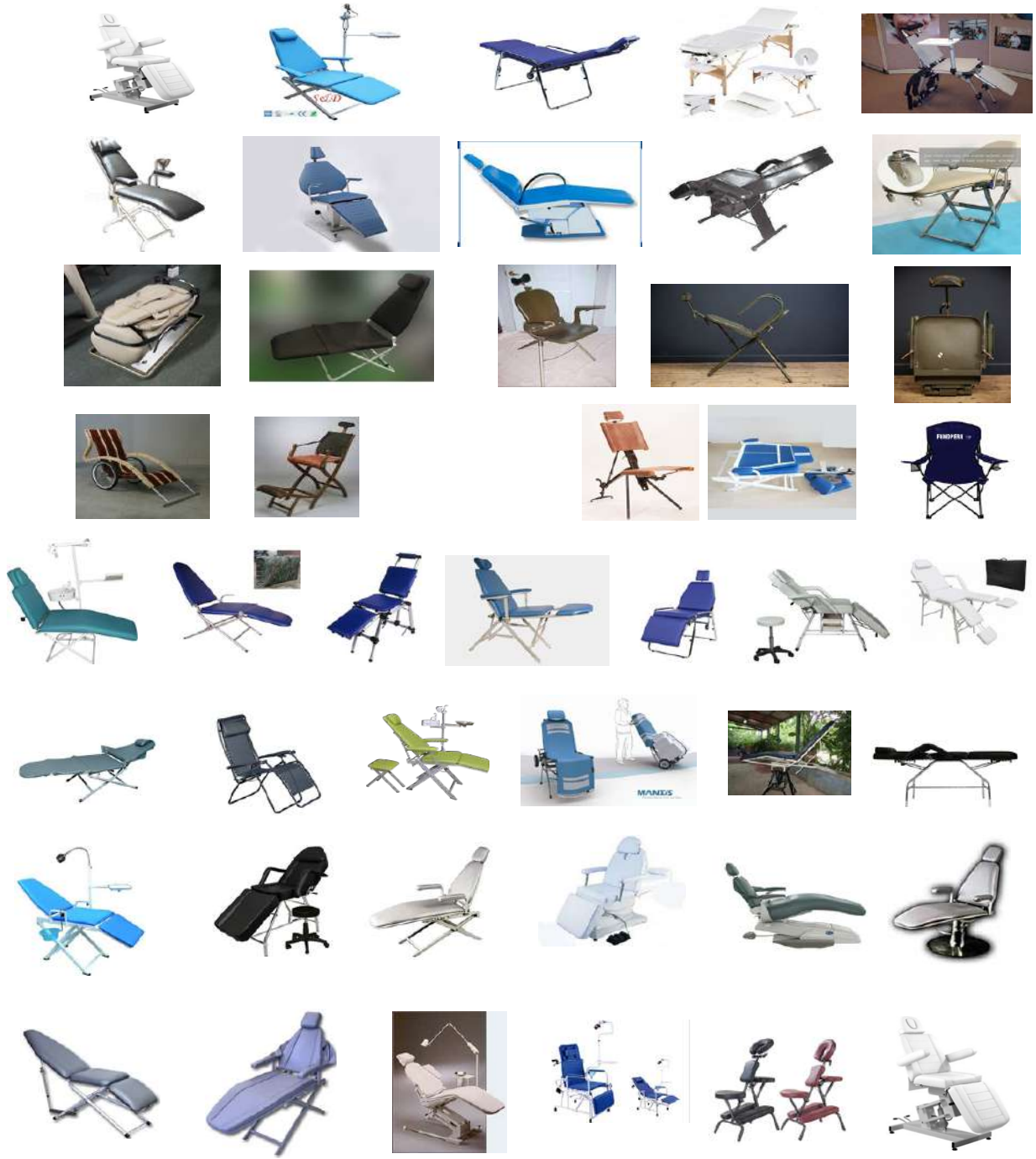


Fig. 7.5 Image Board

7.4. Visual Perception Matrix

Visual perception is the ability to give meaning to what is seen. It is not the actual ability to see, but instead, it is the person's ability to comprehend what the eyes see. This is a good tool for concept generation and placement of the product.

This was done as part of a workshop conducted at IDC, by Mr. Ashok Panvalker, Head of P designs, Pune.

All products similar to what I am ideating were considered for this, even products available abroad were taken and images were used to be made an image board. This included all sorts of potable dental chairs, Which had different mechanisms and materials.

As normal practice, the forms and visual perception such as v of the products are considered for validating them and sorting them. But for dental chairs, the functionality and the fold-ability is what matters. Products were chosen according to that.

Fig. 7.5

The visual perception matrix is a 5x5 matrix where each row and column represents a property/ feature. For the exercise, the matrix was made out on a sheet of paper, where the images would be stuck upon later on(Fig7.5).

On along X axis, each column is in the order; Traditional, established, actual, distinct, and extreme, respectively. On the Y axis, the rows are is in the order; old-fashioned, known, current, innovative, radical, respectively

The image s are clipped, onto the matrix according the appropriateness. Sorted images are than compared with the ideations and the brief.

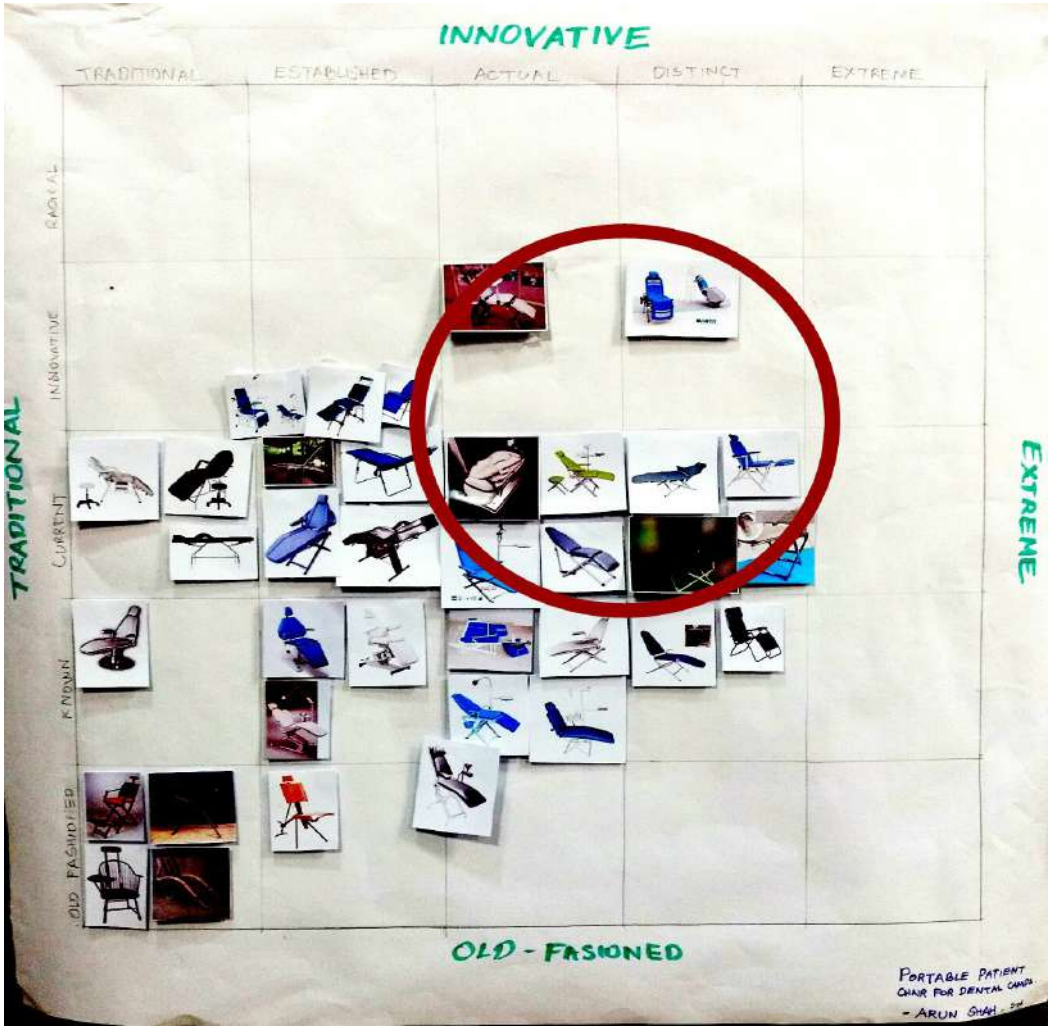
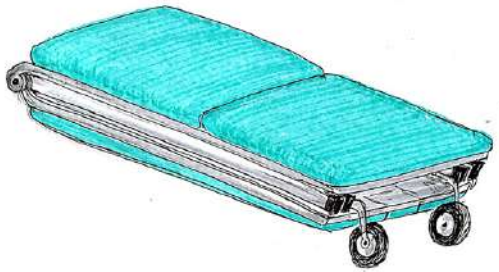


Fig. 7.5

The features of each are different. According to features desired, an area is marked at the matrix. So that the concepts can be made easier. This sophisticated selection makes it easier to draw down to certain limited features, which are required. Also helps to place the product in the market

Section 8.

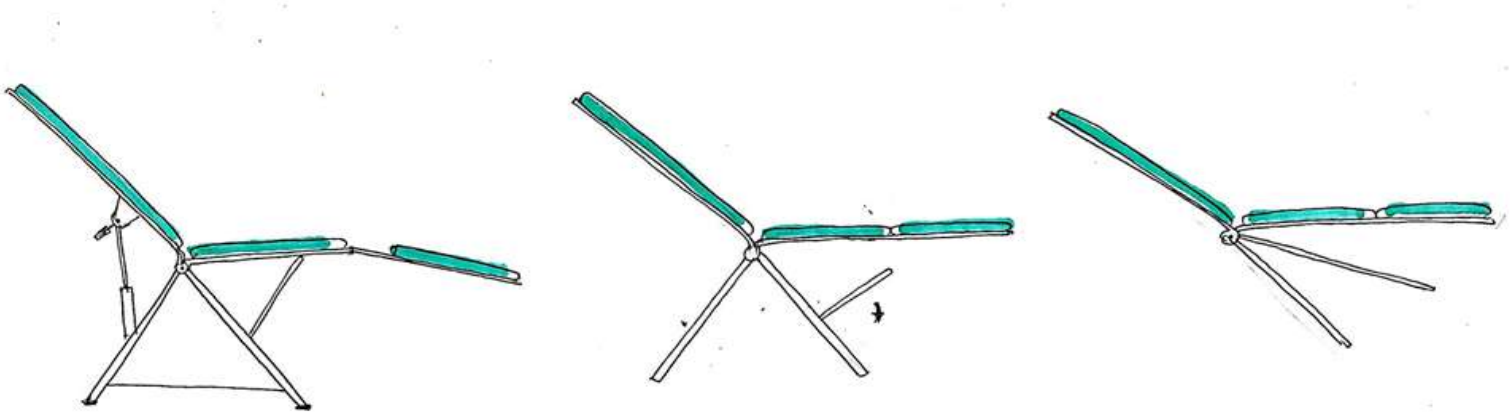
8.1. Concept One



The initial concept is the trolley concept.

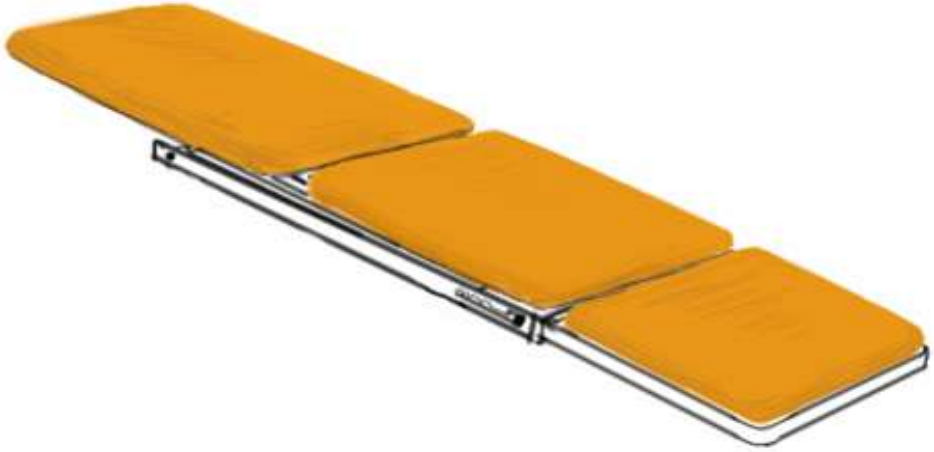
The chair folds into a trolley, with attached wheels. The frame folds into one single frame.

Compatible Materials; Powder coated steel or aluminum frame
Fabric or injection molded PP chair material.



- Backrest adjustment is by hydraulic jack
-
- The entire chair is supported by metallic frame and can be opened in 3 steps; Opening the legs, opening the backrest, opening the leg-rest and seat respectively.
-
- Belt straps are used for the locking of back regs and front legs.
-
- The wheels are detachable.

8.2. Concept Two



Form inspired from stretchers.

This chair can be laid out flat and stacked.

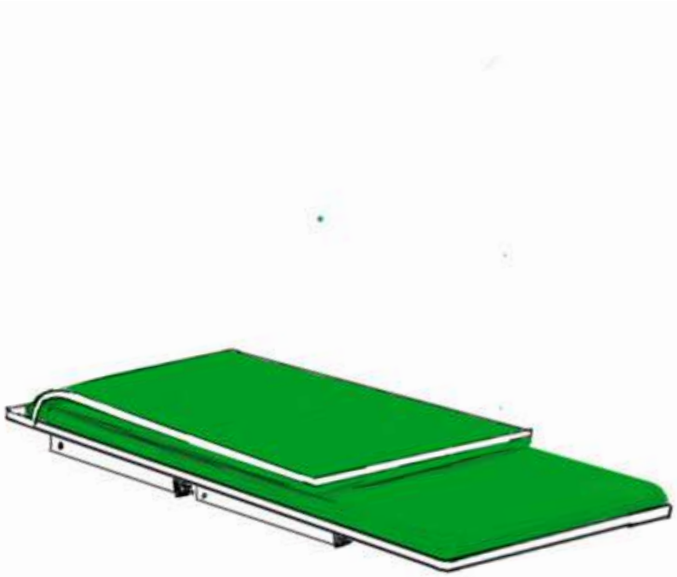
Will consume minimum volume

Backrest mechanism; Slots and lock mechanism.

Cross legged chair, provided with slots for easy folding.

Material for construction; Aluminum and powder coated steel. PU Foam paddings are given for better comfort
Aluminum body is an alternative material for the design.

8.3. Concept Three



Wooden chair concept;
Simple Metallic frame of steel and plywood chair body.

- The folding is through simple connecting rod mechanism
-
- Backrest is adjusted through telescopic pipe mechanism.
-
- Opens up in four stages;
- Opening the front-leg then the back-leg
- Followed by opening the backrest and then joining the backrest for adjustment.

Section 9.
Concept Selection

		Concept One	Concept Two	Concept Three
Convenience of Portability	Convenience in folding and setting up	3	3	3
	Size and compactness	4	3	3
Convenience of operation	Backrest adjustability	4	3	4
	Seat height adjustability	3	3	2
	Legrest adjustment	3	3	-
Materials and manufacture.	Materials	3	3	2
	Ease of manufacture	3	2	4

The concept selection was on basically three priorities. Convenience of portability, convenience in the operation and materials and manufacture. This was a self assessment. For each feature of each concept, a score out of 10 was given.

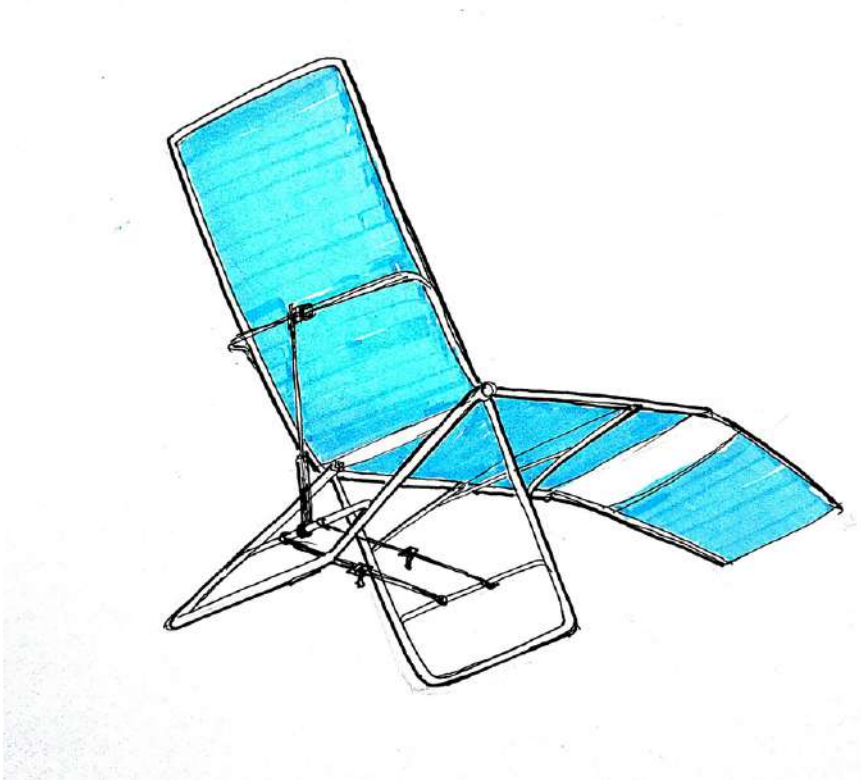
The total of Each example was compared. The highest scored was concept one. Hence it was selected.

Section 10.
Concept Alterations

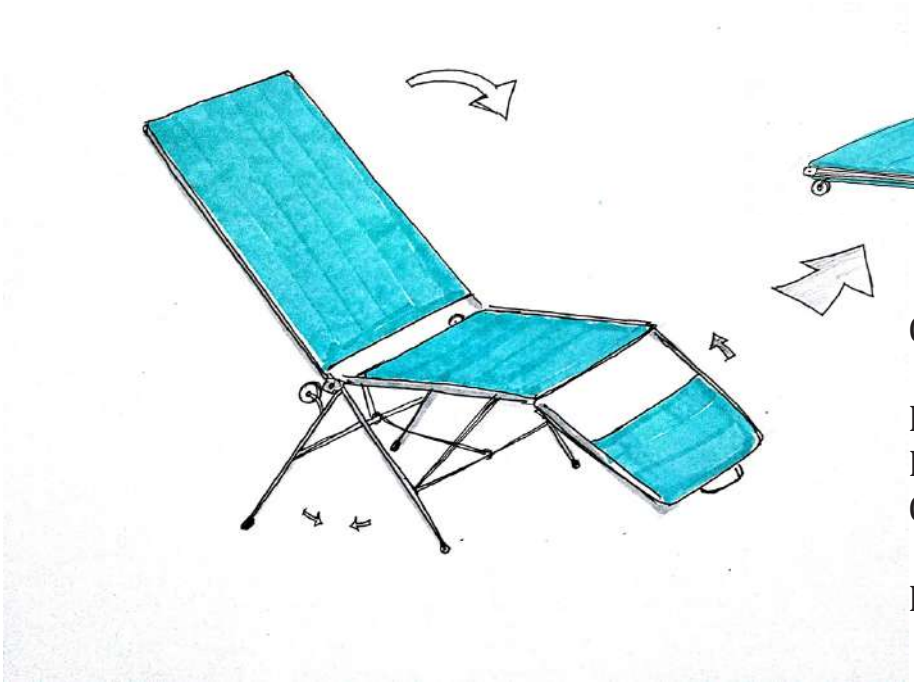
Concept one was selected, The alterations of it with respect to different materials were to be explored.

Concept One - A

Materials;
FRP/Injection Molded PP and dye cast aluminum
Full plastic seat, backrest and legrest
Detachable leg-rest



Concept One - B
Materials;
Materials; Tubular SS, Synthetic fabric
Fabric / woven frame gives improves the comfort of the chair.
But leaves hygienic issues as challenge



Concept One - C

Materials;
Powder Coated MS Frame
Compatible with Plywood/ plastic/ fabric.

Metallic framework around entire body

Concept One - D
Materials;
Full aluminum body with padding at seat and backrest

Flat seat; knee angle at 180°

Section 11.
Concept Testing






Concept One-c was a good one to test upon, because the design supported both plastic and fabric.
Based on that concept, there were many mock-ups made. The initial ones were made out of Styrofoam and polystyrene. Then working mocks ups were made, out of PVC and polystyrene. This was testing the fold ability.

11.1. Full Scale Working Jig.






To further understand the issues, a full scale working rig was made for concept one - c.

Materials used; MS pipe (1'' dia., i1mm thick)
MS rod (1 cm dia.)
Plywood (18mm thick)
Weighing Belt, Velcro.

The model is completely works and works fine. IT takes 4 steps to open up the chair. The dimensions were taken to

The chair was tested with different people of different height and weight. The feedback was mixed.

11.2. Activity analysis of a dental camp.

The way operations was done in a dental camp was mocked and a role play - activity analysis was done. I t was fond that using this was way better than using a normal chair for patients. There was very much less stress for reaching and examining the oral cavity of patients at the position. It could be completely folded, and carried.

But then, there were certain issues that was significant, which were similar to the existing design.
There were issues with the material, usability and design which has to be looked into.

11.3. Issues Found

#1; Improper/Absence of Headrest - it is important to give proper support to the head, since the operations are concentrated at the oral cavity.

#2; Overweight - the chair is supposed to be lightweight. It becomes extremely difficult for one person to set up the chair and to fold up the chair

#3; Wider knee angle - the sitting position is comfortable, but the wide knee angle in the chair makes the patients to stretch out the legs a little, which is uncomfortable for certain patients.

#4; No Armrest - There should be some support for the arms.

#5; Size - When folded, the chair still is huge and has to be made compact when folded

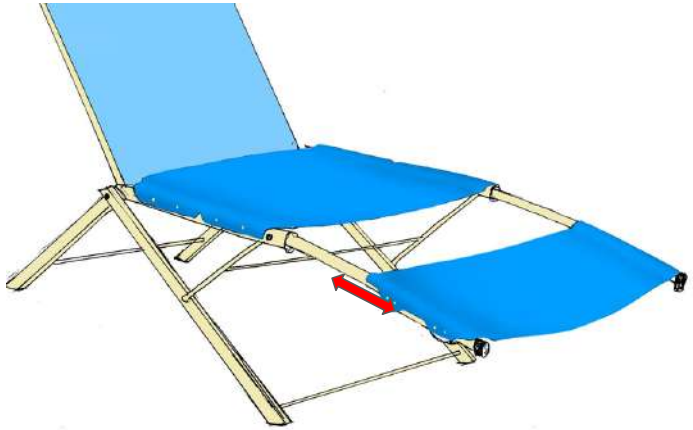
Section 12.
Final Design

Materials;

Stainless steel

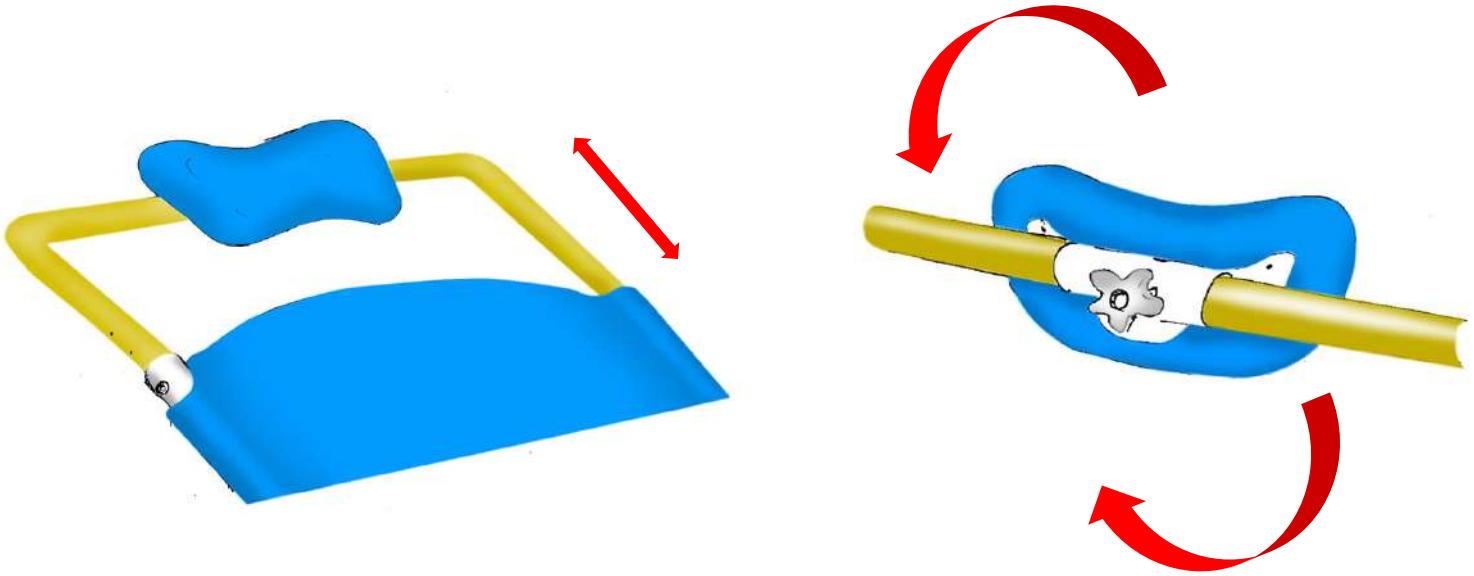
Plastic(Injection molded PP)/FRP

Angle adjustable backrest and Dual support rods, ensuring more sturdiness.

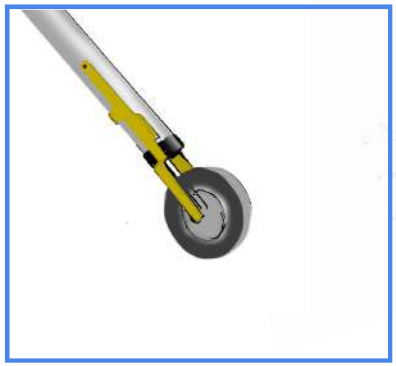


Mechanism for making it compact #1;
Sliding Leg rest

Mechanism for making it compact #2;
Hinged leg rest.



Adjustable headrest;
The angle and the height of the headrest can be adjusted according to different patients and different operating positions



Attached foldable wheels for better maneuverability;

Folding wheels make the chair to be used as a trolley bag, a far better way to carry when compared to the current design.

12.1. The Final Product

The design of the headrest was minimalised.

Labelled image of the final product
(Scaled Model)

The Folding Mechanism of the Chair

1. The Headrest is Slided in

2. The footrest is folded up

3.The backrest support is unlocked and folded down

4.Seat Support is unlocked and folded down

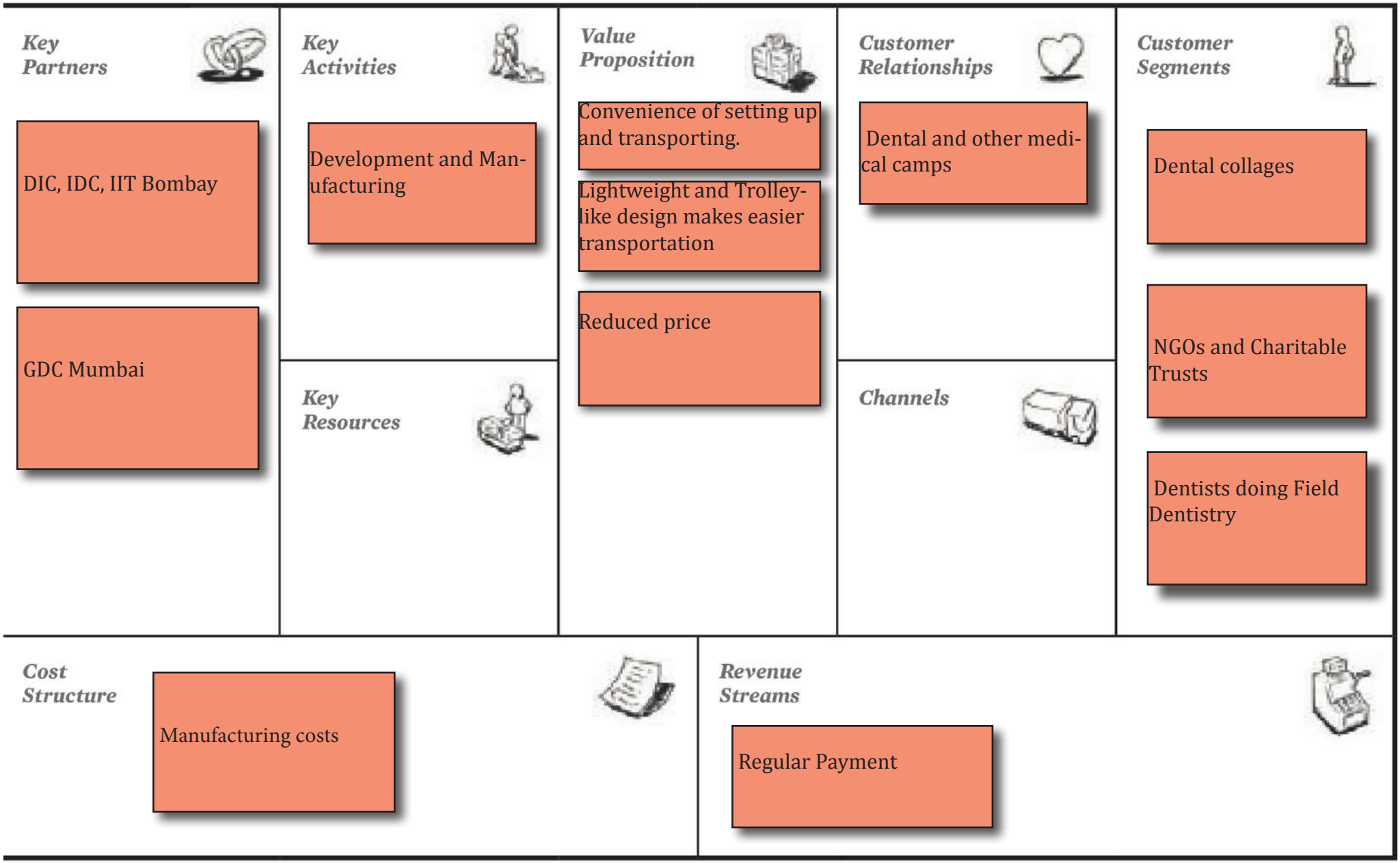
5. The legs are closed and strapped.

Section 13.
Product Planning

13.1. SWOT Analysis

STRENGTHS	WEAKNESSES
• Better portability than similar products • Easier to setup and use than similar products. Do not need more than one person to set it up. • Lighter • Better to work on, Adjustable headrest. • Have better ergonomics. • Cost effective	• The setting up include multiple steps • Chair looks light so might look like a fragile structure. • No Armrest • Manual adjustments • Not equipped with hydraulic jack
OPPORTUNITIES	**THREATS**
• To extend the design to be used as a carrier for the dental units, a proper trolley. • To use the chair for other purposes like blood donation, general diagnosis etc. • Can be used for training and demos	• Advanced Mobile dental clinics. • Imported chairs.

13.2. Business Model Canvas



13.3.Value Proposition

Benefits consumer expects from the product

- Adjustable backrest
- Sturdy design
- Adjustable headrest
- Armrest
- Padding
- Easier to carry
- Consumes less space when folded

What has been put forward.

- Adjustable headrest and backrest.
- Trolley design - Easier to transport and carry
- Sturdy
- Cost effectiveness

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